ALUMINUM

Project Fact Sheet

Two-Phase Hot Deformation Model

Benefits

Success in the research effort and subsequent implementation in the domestic aluminum industry would provide:

- An energy savings of 60.7 billion Btu per year
- A reduction in carbon dioxide production of 7.35 million pounds per year
- A total cost savings to the U.S. aluminum industry of $2.8 million per year
- The elimination of reheating for approximately 50 percent (100 million pounds per year) of the applicable sheet and plate in the U.S.
- Reduction in scrap of approximately 7.5 percent

Applications

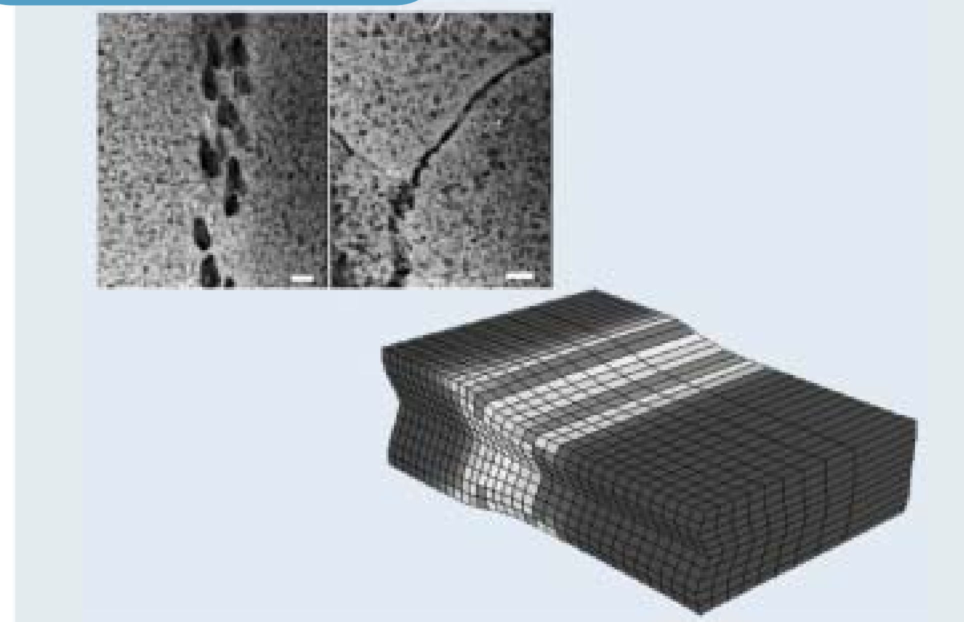
Highly alloyed aluminum is widely used in products ranging from packaging to transportation. The development of thermomechanical deformation models will permit more energy and cost-efficient processing of sheet metal products.

Development of a two-phase model for the hot deformation of highly-alloyed aluminum

Conventional processing methods for highly alloyed aluminum consist of ingot casting, followed by hot rolling and thermal treatments. Highly alloyed metals are more susceptible to the development of defects in hot rolling, due to localized melting along the chemistry-rich grain boundaries. Defects result in lost productivity and wasted energy because of the need to remelt and reprocess the material. Improved quality and yield for both conventional hot rolling and continuous casting will be achieved only through understanding of the flow of the alloyed aluminum at temperatures approaching the melting point.

This research is developing a fundamental understanding of deformation of wrought alloys with emphasis on the upper temperatures bounding the hot working regime. Traditional constitutive models consider the alloy as a single phase system. This research is developing a two-phase (grain interior and boundary) mathematical description. The focus on hot rolling provides a computation platform for optimization of the Thermomechanical Processing Window (TPW) within industrial capabilities of temperature and deformation rate. This research will provide the computational tools to allow "faster and cooler" processing of highly alloyed aluminum.

Hot Deformation Model



The micrograph on the left shows TEM characterization of the precipitate structure. The model on the bottom right is a computer simulation of the hot rolling process.

Project Description

Goals: This research is developing a mathematical description for the high-temperature deformation of aluminum alloys using a two-phase model.

The specific goals of this research are to:

- gain improved fundamental understanding of hot deformation in highly alloyed systems of commercial relevance;
- formulate a material description for hot deformation of aluminum alloys that accounts for temperature-dependent response of the grain boundaries;
- integrate the resulting material model into parallel finite element codes; and,
- conduct detailed analysis specific to production hot rolling, while developing a general framework for simulation of other hot deformation processes.

Progress and Milestones

Year One
- Measure properties of bulk compression
- Design and complete successful trial of tension test fixture

Year Two
- Conduct mechanism identification through in-situ Transmission Electron Microscopy (TEM) testing
- Formulate constitutive model based on TEM results
- Fit parameters to match bulk test data

Year Three
- Validate computer simulation through comparison to in-situ TEM results
- Simulation of hot rolling process

Commercialization Plan

The technology developed within this project will be made available to the aluminum community through journal publications and/or technical presentations. Industry will incorporate this knowledge to facilitate commercialization.

Project Partners

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Alcoa Technical Center
Alcoa Center, PA

Los Alamos National Laboratory
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